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Enhanced phonological facilitation and traces of concurrent word form activation in speech production: An object-naming study with multiple distractors

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In the present study, we extended the classic picture–word interference paradigm by the presentation of multiple distractor words (Experiment 1) to reexamine whether the word forms of semantic alternatives receive activation in the course of object naming. Experiment 2 showed that phonological facilitation can be magnified by the presentation of multiple words that share overlapping initial and final segments with the target name. Experiments 3 and 4 tested for traces of nontarget phonological activation with multiple distractors, which enhances the chances of detecting such effects. These experiments revealed a consistent pattern of interference effects induced by words that were related to a semantic category member, consistent with theories assuming phonological activation of nontarget alternatives.

In this article we introduce a modified version of the classic picture–word interference paradigm with multiple distractor words. We examine whether the presentation of more of the same type of distractor information yields more of the same type of effect in picture naming—that is, enhanced semantic interference and phonological facilitation. This paradigm was then used to reinvestigate a traditional and controversially discussed issue in speech production research—namely, the flow of information through different processing components involved in single-word production.

Current models describing the microstructure of speech production at the level of single words classically distinguish between semantic, syntactic, and phonological processes required for producing a meaningful utterance (e.g., Dell & O'Seaghdha, 1991, 1992; Levelt, 1999; Levelt, Roelofs, & Meyer, 1999). However, the agreement ends when the discussion turns to the specific temporal

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and functional relations between these processes. For example, some models argue for a direct mapping between concepts and word forms (e.g., Caramazza, 1997; Humphreys, Riddoch, & Quinlan, 1988; Starreveld & La Heij, 1996) while others assume a syntactic processing level, typically referred to as the lemma-level (Kempen & Huijbers, 1983; Levelt, 1989), mediating between conceptual processing and the retrieval of the respective word form (e.g., Dell, 1986; Levelt et al., 1991; Peterson & Savoy, 1998; Roelofs, 1992). In the present paper, we focus on the nature of information transmission from lexical items (lemmas) onto their respective word forms. We adopt the assumption that speech production proceeds from a conceptual stage specifying the intended meaning of the utterance through a stage of lexical-syntactic processing that includes the selection of the target lexical entry (i.e., the lemma), to a stage of morpho-phonological encoding before the utterance can be articulated.

The nature of information transmission between lemmas and word forms

In a comprehensive outline of their speech production model, Levelt et al. (1999) give a detailed description of the processes underlying word production. One characteristic feature of this model is the assumption of discrete information transmission from lemmas to word forms, as is described below. First, a target concept is selected (for example, upon viewing a picture of a monkey, the concept node MONKEY is activated). This concept spreads activation to the appropriate lexical item, the lemma *monkey*. In parallel, the concept spreads activation to related concepts (e.g., semantic category members such as ELEPHANT and CAMEL, category descriptions such as ANIMAL, and associatively related concepts such as BANANA, etc.), which activate their corresponding lemmas and in turn receive additional activation via feedback from the lemma level. As a result of this mutual spread of activation between concepts and lemmas, not only the target lemma *monkey*, but also the lemmas of potential semantic competitors such as *elephant* and *camel* become active. What follows is a lexical selection mechanism based on Luce's ratio (cf. Roelofs, 1992). The probability for target lemma retrieval depends on the ratio of the target lemma's activation and the sum activation of all its competitors.

With lemma selection, syntactic features such as word class, syntactic gender, or number become available. After the successful selection of the target lemma, the corresponding phonological code is retrieved in a discrete subsequent step. Because phonological processing can only begin after the completion of lemma selection, it is restricted to the target and does not involve the word forms of competitors. Accordingly, the word form to be retrieved is fully determined by preceding semantic and syntactic processes, and phonological factors do not contribute to the selection of the final utterance.

In contrast, cascading models have proposed continuous transmission of information between lemmas and word forms, assuming either feed forward activation only (e.g., Peterson & Savoy, 1998) or feedback from the word form to the lemma level (e.g., Dell & O'Seaghdha, 1991). Both variants of such architecture imply that phonological processing can begin on the basis of partial information. It is therefore not restricted to the word form of the selected lemma but extends to the word forms of potential semantic alternatives of the utterance. Consequently, cascading models predict traces of the phonological activation of semantic alternatives, whereas discrete models predict no such activation.

Distractor effects and concurrent word form activation of lexical competitors

In the classic picture–word interference task, an object is presented for a naming response together with a written or spoken distractor word. The distractors are assumed to interact with the naming response via shared or linked representations between speech perception and production processes and are therefore characterized by their specific relationship to the target picture. For example, the picture–word pairs can be *semantically related* in terms of shared category membership (e.g., target: monkey; distractor: camel), or *phonologically/orthographically related* (e.g., target: monkey; distractor: money). Compared to unrelated words, categorically related distractors slow down naming latencies whereas phonologically related distractors yield facilitation (e.g., Glaser & Düngelhoff, 1984; Lupker, 1979; Schriefers, Meyer, & Levelt, 1990; Starreveld & La Heij, 1995, 1996). The facilitation induced by phonologically related words is assumed to be a consequence of converging activation onto phonological nodes both from word production and from perceptual input representations. This effect is therefore located at the word form level. To our knowledge, it is unclear whether the resulting difference is exclusively due to facilitation from overlapping segments or whether it reflects a combination of facilitation and inhibition from related and unrelated segments, respectively. We are not aware of empirical evidence for or against interference from unrelated segments at the word form level (but see Roelofs, 1997, for arguments for interference from nontarget syllables).

Following Levelt and colleagues (1999) and Dell and O'Seaghdha (1991, 1992) we assume that categorically related words affect picture naming at the level of lexical selection. The bidirectional spread of activation, at the conceptual level and between concepts and their lemma nodes, results in the activation of a set of categorically related concepts and lemmas, the latter competing for selection.[1] The additional presentation of a categorically related word causes an even stronger activation of its lemma and potentially a stronger activation of other related lemmas via shared conceptual features. As a result, lemma selection is delayed relative to the presentation of an unrelated word.

To date the issue of whether nontarget word forms become activated during lexical access has received much attention, but appears to be unresolved. Several comprehensive reviews on the empirical evidence for and against models assuming concurrent word form activation can be found in recent literature (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Cutting & Ferreira, 1999; Damian & Martin, 1999; Ferreira & Griffin, 2003; Jescheniak & Schriefers, 1998; Levelt et al., 1999; Levelt et al., 1991; Morsella & Miozzo, 2002; Peterson & Savoy, 1998; Rapp & Goldrick, 2000); we therefore do not reiterate these reviews in great detail but focus on the basic experimental logic for such a distinction employed here. This paper, like several other reports on the current issue, is a modified version of an experimental logic based on detecting *mediated interference* between speech production (in terms of picture naming) and speech perception (in terms of word reading or hearing), which was introduced by Levelt and colleagues (1991). The term *mediated* refers to an indirect relation between a picture name and a distractor word via a semantic competitor of the target.

To test whether semantically related nontargets are phonologically encoded in the course of picture naming, Levelt et al. (1991) combined picture naming with a lexical decision task on words. The phonological activation of nontargets during picture naming was probed with lexical decisions on the concurrently presented words, which were, in the critical conditions, phonologically related to either an associate of the target (Exp. 5; e.g., picture: sheep; probe word: wood; associate: wool) or a semantic competitor (Exp. 6; e.g., picture: sheep; probe word: goal; competitor: goat), or were unrelated. The rationale behind this paradigm was the following: Only if the word forms of nontarget associates or category members are activated during picture naming should there be an effect on lexical decision latencies when the probe words were phonologically related to an associate or category member, respectively. If, in contrast, only the word form of the target is activated, the related conditions should not differ from an unrelated control.

[1] This account of semantic interference is also consistent with recent models proposed by Bloem and colleagues (Bloem & La Heij, 2003; Bloem, van den Boogaard, & La Heij, 2004), which assume that only one concept is lexicalized but it then spreads activation to a *semantic cohort* of lexical representations.

In line with the latter prediction, no signs of phonological activation of nontargets were observed. Since the identical manipulation successfully affected lexical decision latencies when pictures and words were directly semantically or phonologically related, this finding presents strong evidence that neither associates nor category members of the target word are phonologically activated. This result has since been replicated by Peterson and Savoy (1998) with a similar experimental design, using vocal word-naming responses rather than lexical decisions on the words (Exp. 3) and by Jescheniak, Hahne, Hoffmann, and Wagner (2006). Interestingly, however, Jescheniak and colleagues demonstrated that mediated phonological effects can be observed in children around the age of 7. This finding shows that such distractor effects decrease with age, being present in children with less language proficiency and absent in proficient adults. In the current paper, we adopt the basic logic of the design introduced by Levelt and colleagues—that is, to test for mediated interference effects between picture names and distractor words that are phonologically related to a semantic alternative of the picture. However, instead of measuring lexical decision latencies of the words, we assume that mediated interference will alter picture naming as well as word naming or lexical decisions and therefore focus on naming latencies of target pictures.

Further support for the claim that word form encoding is restricted to the target word comes from an electrophysiological study that shows a clear modulation of the electrical brain response by semantically and phonologically related words presented during delayed picture naming, whereas no such modulation was observed for distractor words that were phonologically related to a competitor (Jescheniak, Hahne, & Schriefers, 2003).

However, proponents of a nondiscrete architecture have argued that the traces of phonological activation of nontargets might simply be too small to be detected with a picture–word interference task (Dell & O'Seaghdha, 1991, 1992) or, as O'Seaghdha and Marin (1997) demonstrate, the effects are "near the limit of the sensitivity of the naming task" (p. 226). In short, such effects might be real, but weak. Supporting evidence for this claim comes from recent studies showing clear signs of concurrent word form activation for synonyms and cognates. For example, Peterson and Savoy (1998) observed faster naming latencies for words (e.g., couch) when they were preceded by a picture with a synonymous name (sofa). Jescheniak and Schriefers (1998) report delayed naming latencies for preferred target picture names (e.g., couch) when the presented distractor words were phonologically related to a synonym (e.g., soda, phonologically related to sofa). Costa et al. (2000) report that bilinguals' naming latencies are faster when the picture name in the target language has a phonologically similar name in the nontarget language. These findings suggest that the chances for detecting phonological coactivation increase with increasing semantic overlap between the target and a lexical competitor. This is presumably because a large semantic overlap between target and competitor results in a stronger activation of the competing lemma and, as a consequence, in a comparatively strong activation of the competitor's word form.

The question remains, however, as to whether these findings represent a general pattern of phonological coactivation or whether instead they represent an exception to a general rule. For example, Levelt and colleagues (1999) argue that synonyms are typically equally appropriate in a given context, and therefore it might be the case that both strongly activated lemmas are selected. Multiple lemma selection would likewise result in the activation of both word forms without the assumption of continuous transmission. Whether or not it is contextually appropriate to refer to an object by code switching into a different language, we leave for the reader to decide.

OUTLINE OF THE EXPERIMENTS

To summarize, there are two potential accounts for the contrasting results regarding concurrent phonological activation of categorically related competitors. First, information transmission from lemmas to their word forms is continuous but the traces of phonological coactivation are subtle and therefore only detectable when semantic overlap is maximized. Second, information transmission from lemmas to their respective word forms is discrete, and phonological coactivation is restricted to instances of multiple lemma selection. Both interpretations are in line with the observation that only word forms of contextually appropriate competitors such as synonyms are observed but not the word forms of (contextually less appropriate) ordinary category members.

In the series of experiments reported below, we present yet another approach to distinguish between discrete and cascading architectures by enhancing the chances for detecting effects of non-target word form activation. For this purpose, we presented multiple related and unrelated distractor words, presuming that the presentation of more of the same type of information yields more of the same kind of effect. Experiment 1 tested whether the effects induced by multiple words which provide the same type of information (e.g., two semantically related words, two phonologically related words with overlapping initial segments, or two unrelated words) are comparable in nature to the classic effects observed with the picture–word interference paradigm. This experiment demonstrates that multiple distractor presentation results in typical semantic interference and phonological facilitation effects. Experiment 2 demonstrated that phonological facilitation effects can be magnified considerably by presenting multiple phonologically related words with initial and final segmental overlap. This multiple distractor method was then used to test for word form activation of semantic category members in Experiments 3 and 4 that are unlikely to be contextually appropriate alternatives of the target name.

EXPERIMENT 1

In this experiment we assessed whether the basic effects of simultaneously presenting multiple words of the same type in a picture–word interference (PWI) situation meets two requirements for the subsequent experiments. First, we tested whether these effects are comparable in nature to the effects of single distractors. To our knowledge, multiple words have never been presented within the classic PWI paradigm.[2] Hence, it is unclear whether two visually presented words with the same relation to the target induce the classic effects of semantic interference and phonological facilitation. The second aim of this experiment was to test whether the information introduced by a second distractor evokes additional semantic interference and/or phonological facilitation effects or whether, in contrast, it is entirely redundant. Thus, we assess the conditions under which magnitude changes in distractor effects can be observed and whether these changes reflect modifications in the speech production system rather than more general mechanisms, such as a higher chance for perceiving a word when two words, instead of one, are presented (see below).

The visually displayed distractors were semantically related, phonologically related, or unrelated to the target picture. In the single conditions, distractor words were paired with a row of *x*s (Group 1) or a single word was presented twice (Group 2); in the double distractor conditions, two words of the same type were presented (e.g., two different semantically related words, two different phonologically related words with initial segmental overlap with the target name, or two different unrelated words).

The predictions for multiple semantically related distractors are as follows. As discussed above, we assume that semantically related words affect picture naming at the lemma level. Reciprocal spread of activation at the conceptual level and between concepts and lemma nodes

[2] Schriefers and colleagues (Schriefers, Teruel, & Meinshausen, 1998) presented a single distractor in two modalities to ensure that the distractor was processed. However, the number of distractors was not a manipulated variable nor were theoretical implications drawn from multiple word presentation as such.

results in the activation of semantically related lexical competitors when a picture is named in the presence of a categorically related word. This delays target lemma selection more than the presence of an unrelated word. Presenting two categorically related words should produce strong activation of two lexical competitors and furthermore increase the activation level and number of other related concepts via bidirectional links to the conceptual processing level. Adopting a selection mechanism based on the ratio of the target activation and the sum activation of all other lemmas as described in the Introduction, we predict stronger semantic interference effects when two related words are presented than with the single-word condition and the repeated presentation of a single word.

The predictions for the phonological condition are less clear. Presenting two words with initial segmental overlap might result in a faster activation of the target word form because the respective segments are activated more strongly due to overlapping segments between picture name and two distractor words. However, since both related words provide almost identical information (initial segmental overlap) it is also conceivable that the second word does not speed naming latencies significantly more than does a single related word or a single word presented twice.

The two different single conditions, one related word presented with a row of *x*s or a related word presented twice, were included to address a potential perceptual effect stemming from the simultaneous presentation of two distractor words. Specifically, besides enhanced interactions between language perception and production processes, magnitude differences in the effect size between single and multiple distractor conditions might simply be due to differences in perceptual processing. For instance, if, irrespective of the number of words presented, only one word is fixated in a given trial, the probability for perceiving a distractor would be 100% when two related words are presented and merely 50% when one related word is presented in combination with, for example, a row of *x*s or an unrelated word. Thus, the two unrelated conditions should help us to determine whether any magnitude differences for multiple distractor effects originate from lexical sources. According to the perceptual account above, there should be no difference between the multiple distractor conditions and the single distractor presented twice.

Method

Participants

A total of 36 adult native Dutch speakers from the Max Planck Institute for Psycholinguistics subject pool were paid for their participation. All reported normal or corrected-to-normal visual accuracy and normal colour vision. The participants were randomly assigned to Group 1 or 2.

Stimuli

The target picture set consisted of 36 black-and-white line drawings of common objects equally distributed between six semantic categories (animals, furniture, musical instruments, clothing, tools, and vegetables). Target names had a mean frequency of 42 occurrences per million (range 0–300). All pictures were scaled to 3.5 × 3.5 cm. The distractor words were presented in red and were arranged one above the other. Relative to the picture, the words were placed to have maximal integration without obscuring the visibility of the picture. The relative position of distractors within a given picture was constant across the experimental conditions. The size of the pictures and words was comparatively small such that both words were presented within approximately one degree of visual angle to ensure that both distractor words could be perceived by the participants. In Group 1, each target picture (e.g., elephant) was paired with three single distractor conditions: a semantically related word combined with a row of *x*s (SX; e.g., camel xxxx), a phonologically related word combined with a row of *x*s (PX; e.g., elevator xxxx), or an unrelated word combined with a row of *x*s (UX; e.g., skirt xxxx). In Group 2, the same word was presented twice (SS: camel camel; PP: elevator elevator; UU: skirt skirt). Additionally, in both groups, three double distractor conditions were constructed consisting of two semantically related words from the same category (S2; e.g., camel sheep), two phonologically related words with initial segmental overlap (P2; e.g., elevator electrode), or two unrelated words (U2; e.g., skirt castle).[3] The relative position of the distractor words (above or below another related word and above or below a row of *x*s) was counterbalanced across stimuli. Semantically related and unrelated distractors were taken from the set of picture names (cf. Roelofs, 1992); the phonologically related words were not picture names. Phonologically related distractor words shared at least the onset and nucleus of the initial syllable of the target name. The mean number of shared segments was 2.4 (range 2–6). Target names and phonological distractors had the same stress placement in 47 of the 72 cases. Phonologically related distractor words had a mean frequency of 42.25 occurrences per million (range 0–1,028). The stimuli used are listed in Appendix A.

Procedure

Each trial began with a fixation cross displayed in the centre of a light-grey screen. After 500 ms the fixation cross was replaced by a picture–word pair, which was presented for 2 s, resulting in an interstimulus interval of 2.5 s. The stimulus onset asynchrony (SOA) in this and all following experiments was 0. Participants were instructed to name the picture as fast and accurately as possible. No instructions were provided regarding the words. Naming latencies were measured with a voice key during the entire duration of picture presentation.

The experiments started with a practice block in which participants named each picture and were corrected if necessary. Then, four experimental blocks of 126 trials each were carried out, the whole session lasting about 30 min. Each picture was presented two times in each condition; each of the six categories was repeated 12 times per condition. The pictures were presented in a pseudorandomized sequence to prevent repeated picture presentations in consecutive trials.

Results

Table 1 presents the mean reaction times (RTs) for correct naming trials and mean percentages of errors in the six experimental conditions of the two groups in Experiment 1. The following treatment of the raw data was performed in the present experiment and all subsequent experiments: Trials with incorrect naming, stuttering, mouth clicks, or vocal hesitations and trials with naming latencies that deviated more than 2.5 standard deviations from a participant's mean RTs in the relevant experimental condition were discarded from the analysis. For the total number of excluded trials per condition see Table 1.

Mean RTs were submitted to analyses of variance (ANOVAs) with the between-subjects factor group (Group 1 and 2) and the within-subjects factors distractor type (semantically related, phonologically related, or unrelated) and number of words (single or double). All ANOVAs were calculated with participants (F_1) and items (F_2) as random variables.

Overall, the naming latencies tended to be faster in Group 1 than in Group 2, *M*diff = 38.9 ms, $F_1(1, 34) = 1.7$, $p = .19$, $MSE = 46{,}117$; $F_2(1, 70) = 18.7$, $p < .001$, $MSE = 18{,}738$. There were main effects of distractor type, $F_1(2, 68) = 91.9$, $p < .001$, $MSE = 679$, ϵ[4] $= 0.96$; $F_2(2, 140) = 47.9$, $p < .001$, $MSE = 2{,}759$, $\epsilon = 0.88$, and number, $F_1(1, 34) = 18.2$, $p < .001$, $MSE = 356$; $F_2(1, 70) = 6.5$, $p < .05$, $MSE = 2{,}167$, and an interaction between distractor type and number, $F_1(2, 68) = 7.1$,

[3] In addition to the distractor conditions described here, a mixed condition was also included, which consisted of one phonologically related word and one semantically related word (e.g., MIX: camel elevator). This condition was included to investigate the interaction between distractor-induced effects but is not directly related to the issue of boosting effects. It is therefore not discussed further in this paper. For additional information about the interaction between effect types, see Melinger and Abdel Rahman (2004).

[4] When the sphericity assumption was violated in any of the experiments the respective Huyhn–Feldt ϵ value for correction is reported together with the uncorrected degrees of freedom (Huynh & Feldt, 1976).

Table 1. *Mean reaction times, standard errors of means, error percentages, and percentage of trials excluded from the analysis for the two groups of Experiment 1*

Group			*RT*	*SE*	*Errors*	*Excluded*
1	Semantically related	Single	796	23.1	4.6	7.5
		Combined	826	26.3	5.9	8.7
	Phonologically related	Single	749	20.3	3.0	5.7
		Combined	753	20.8	3.8	7.0
	Unrelated	Single	773	19.7	3.2	6.0
		Combined	782	22.6	4.8	6.7
2	Semantically related	Single	839	21.3	2.4	5.1
		Combined	856	18.9	2.6	5.3
	Phonologically related	Single	793	20.9	1.8	4.8
		Combined	787	19.9	1.5	4.6
	Unrelated	Single	811	18.3	2.4	5.2
		Combined	824	20.8	1.4	3.8

Note: RT = mean reaction times (in ms). *SE* = standard errors.

$p < .05$, $MSE = 395$; $F_2(2,\ 140) = 4.6$, $p < .05$, $MSE = 1{,}697$. Group did not interact with any other factor, nor was there a three-way interaction between group, distractor type, and number, all Fs < 1.4.

Separate ANOVAs were calculated for the semantically related versus unrelated words and the phonologically related versus unrelated words to investigate the nature of the overall main effects and interaction more closely. For the semantic versus unrelated condition, the numerical difference between the single and multiple distractor conditions (Mdiff $= -23$ ms for the semantic condition and -10.5 ms for the unrelated condition) suggests that the magnitude of the semantic interference effect increases when multiple distractors are presented. This impression was confirmed by the ANOVA yielding main effects of distractor type, $F_1(1,\ 34) = 46.7$, $p < .001$, $MSE = 769$; $F_2(1,\ 70) = 28.3$, $p < .001$, $MSE = 2{,}795$, and number, $F_1(1,\ 34) = 26.3$, $p < .001$, $MSE = 402$; $F_2(1,\ 70) = 10.4$, $p < .01$, $MSE = 2{,}210$, and, most importantly, an interaction between distractor type and number, $F_1(1,\ 34) = 3.4$, $p = .07$, $MSE = 424$; $F_2(1,\ 70) = 3.7$, $p < .05$, $MSE = 1{,}905$. The factor group was again not significant except for the items analysis, $F_2(1,\ 70) = 15.7$, $p < .001$, $MSE = 14{,}371$, nor was the interaction of group with any other factor significant, Fs < 1.6.

In contrast to the observed increase in semantic interference, the number of distractor words did not affect the magnitude of the phonological facilitation effect (Mdiff $= -1.5$ ms). For the phonologically related versus unrelated condition there was a main effect of distractor type $F_1(1,\ 34) = 60.1$, $p < .001$, $MSE = 445$; $F_2(1,\ 70) = 30.7$, $p < .001$, $MSE = 1{,}759$, whereas the effect of number was not reliable, Fs < 1.9. The interaction between distractor type and number reached statistical significance in the subjects analysis, $F_1(1,\ 34) = 3.8$, $p < .05$, $MSE = 345$, but not in the items analysis, $F < 1$. Because there was a numerical difference between the single and multiple distractor conditions only for unrelated words (Mdiff $= 10$ ms) and not for phonologically related words (Mdiff $= 1.5$ ms), this interaction can be attributed to the slightly faster naming latencies in the single than in the multiple unrelated distractor conditions rather than to enhanced phonological facilitation.

Post hoc comparisons between the respective single related and unrelated distractor conditions revealed the typical RT pattern of semantic interference, Mdiff $= 25.2$ ms, $t_1(35) = 4.3$, $p < .001$; $t_2(71) = 3.0$, $p = .002$, and phonological facilitation, Mdiff $= -21.1$ ms, $t_1(35) = -5.0$, $p < .001$; $t_2(71) = -3.4$, $p < .001$. Likewise, naming latencies were slower in the double distractor condition when the word pairs were semantically related to the target

(S2) than in the respective unrelated condition (U2), $M\text{diff} = 38.1$ ms, $t_1(35) = 6.6$, $p < .001$; $t_2(71) = 5.1$, $p < .001$, whereas they were faster for phonologically related word pairs (P2) than in the unrelated (U2) condition, $M\text{diff} = -33.3$ ms, $t_1(35) = -6.5$, $p < .001$; $t_2(71) = -4.4$, $p < .001$. The single comparisons suggest that the basic effects of semantic interference and phonological facilitation are also present when multiple distractor words of the same type are presented.

Discussion

The results of Experiment 1 demonstrate that the classic RT pattern of semantic interference and phonological facilitation in the PWI paradigm is also present when multiple words are presented. This is a necessary precondition for the main experiments in this study.

However, results also indicate that the influence of multiple word presentation on the magnitudes of the respective effects differs between semantically and phonologically related words. Relative to the single conditions (a related word combined with a row of *x*s in Group 1 and a related word presented twice in Group 2), we observed a significant increase of the semantic interference effect when multiple words of the same type were presented. However, no such boost was present for phonological facilitation. Multiple phonologically related words with overlapping initial segments did not induce faster RTs than did single phonologically related words, irrespective of whether the latter were presented with a row of *x*s or were presented twice. Thus, although multiple distractor effects are not seemingly different in nature from the classic PWI effects, presenting more of the same type of information does not necessarily result in an increased magnitude of the respective effect.

Our account for this discrepancy is that the second word in the *semantic condition* introduces different aspects of the same type of information. For example, distractor words like camel and sheep accompanying the target picture elephant introduce complementary semantic features within the same category of animals, which should result in the activation of a higher number of active lexical competitors; additionally, both distractors activate their lemmas and should therefore be equally strong competitors for the target lemma. Assuming competition between the target and all other active lemmas based on Luce's ratio, the probability for target lemma selection directly depends on the proportion of its activation relative to the sum activation of all other lemmas. Therefore, two strongly activated lexical competitors and potentially a bigger number of active competitors should cause slower selection of the target lemma than in the typical PWI situation where only one strong lexical competitor is active. This interpretation is supported by the observation that multiple semantically related words induce stronger interference not only compared to single words (Group 1) but also compared to a situation in which a single word is presented twice (Group 2).

In contrast, the information provided by the second related word in the *phonological condition* might be viewed as entirely redundant because both words have initial segmental overlap with the target name. Therefore, the information provided in the multiple distractor condition does not substantially exceed the information available in the single distractor conditions, irrespective of whether a single word is presented with a row of *x*s or a single word is presented twice. Theoretically, it is conceivable that the segments of the picture name are activated stronger and, as a consequence, faster when two distractors provide the same segmental information. However, the present results suggest that maximal phonological facilitation can be achieved by a single word alone.[5]

[5] An additional factor that may have obscured evidence for a phonological boost is the extra cost associated with processing two distractor words rather than one (even one presented twice). It is possible that this extra processing cost, together with the general redundancy of the overlapping phonological information contributed by the two distractor words, resulted in the absence of an observable phonological boost.

Thus, according to this view the observed boost of semantic interference may be due to stronger lexical competition induced by the presence of a second semantic competitor, whereas, critically for the present purpose, the failure to observe a clear boost in phonological facilitation is due to the redundancy of the information provided by the second word. Consequently, we predict that additional *complementary* phonological information should result in a magnification of phonological facilitation similar to the observed boost of semantic interference effects in Experiment 1. This prediction is tested in Experiment 2 where two phonologically related words with initial and final segmental overlap are presented.

Finally, the results of Experiment 1 demonstrate that multiple distractor effects are located within the speech production system. An alternative explanation for boosted effects when two words are presented was sketched in the introduction: If participants perceive only one word together with a given picture, they are guaranteed to hit a related word in the double distractor condition whereas the chances for perceiving a related word in the single conditions shrink to 50%. However, given these assumptions, there should be no difference between the effects of two different semantically related words versus one semantically related word presented twice because the chances for perceiving a related word are identical. Furthermore, according to this scenario, a boost of phonological facilitation should be as likely as the observed boost of semantic interference, which is in contrast to our findings. Therefore, we are confident that multiple distractors can be used—and offer new possibilities—to investigate the interplay of different processing stages in speech production. Because the main aim here is to test for traces of concurrent word form activation with multiple phonologically related words, we focus on the effects of these distractors in the remainder of the study.

EXPERIMENT 2

Here, we examined more closely whether the magnitude of the phonological facilitation effect can be boosted by presenting multiple words with a phonological relationship to the target picture name. Because the literal presentation of "more of the same" phonological information (that is, two different words with initial segmental overlap) is not sufficient to boost phonological facilitation effects significantly (cf. Experiment 1), we presented two words that provided complementary phonological information—namely, a combination of word-initial and word-final segmental overlap. The pictures (for example a dolphin; Dutch: Dolfijn) were presented simultaneously with a distractor pair that represented one of the following four conditions: a phonologically related word with shared initial segments combined with an unrelated word (e.g., Dokter, Tovenaar), a phonologically related word with shared final segments combined with an unrelated word (e.g., Mandarijn, Poel), a combination of phonologically related words, one with shared initial segments and one with shared final segments (e.g., Dokter, Mandarijn), or a combination of two unrelated words (e.g., Tovenaar, Poel).

If each of the simultaneously presented related words in the combined condition contributes to the magnitude of the facilitation, we expect an increased effect that roughly corresponds to the sum of the effects of the individual words presented alone.

Method

Participants

A total of 24 adult Dutch native speakers from the Max Planck Institute for Psycholinguistics subject pool were paid for their participation in the experiment. All participants reported normal or corrected-to-normal visual acuity and normal colour vision. None had participated in the previous experiment.

Stimuli

The target pictures were the same as those in Experiment 1. For each picture four distractor conditions were constructed. As in Experiment 1, these consisted of two visually presented red words, arranged one above the other, which were superimposed on the picture such that they had maximal integration without obscuring the recognizability of the picture. The relative position of the word pairs within a given picture was constant across the experimental conditions. Again, the size of the pictures and words was comparatively small such that both distractors were presented within one degree of visual angle to ensure that both words were perceived by the participants (for approximate comparison between picture and distractor size see Figure 1).

The distractor pairs consisted of (a) one phonologically related word with overlapping initial segments to the target picture name and an unrelated word, (b) one phonologically related word with overlapping final segments to the target picture name combined with an unrelated word, (c) a combination of the phonologically related distractors with initial and final segmental overlap taken from Conditions a and b, or (d) a combination of the two unrelated words, taken from Conditions a and b. Because the mere presentation of a word, irrespective of its relation to the target, affects the reaction times in picture naming (e.g., Schriefers et al., 1990) the related words were presented together with unrelated words in the "single conditions". This allows a

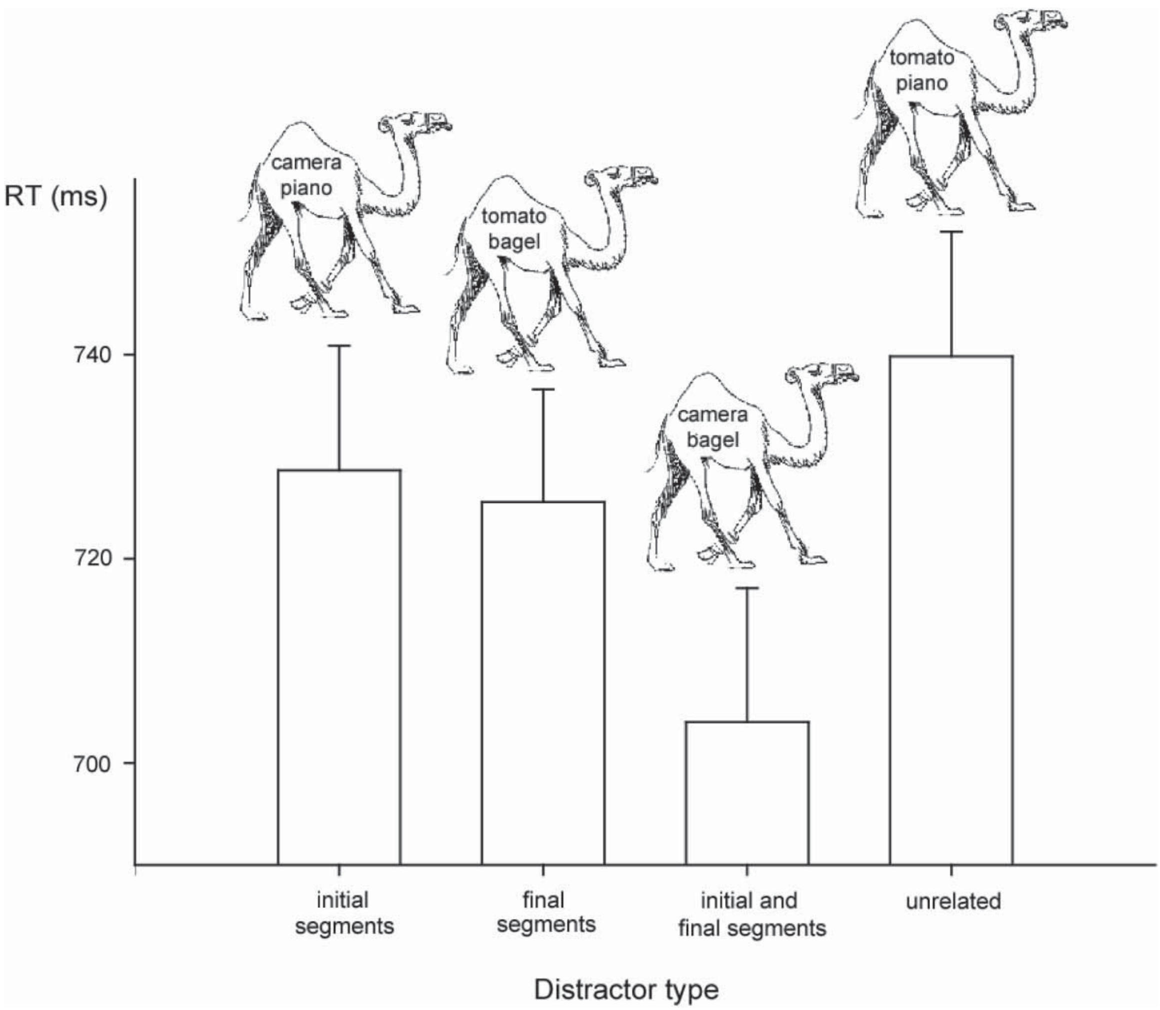

Figure 1. *Mean picture naming latencies for the four conditions in Groups 1 and 2 of Experiment 2 and a hypothetical example of the stimulus presentation conditions in English.*

direct comparison of the effects of single versus multiple related words without the presumably confounding effect of presenting different numbers of words (see Footnote 4). The position of the related words relative to the unrelated words or relative to the related words of a different type was counterbalanced across pictures such that they appeared in the upper position for half of the pictures and in the lower position for the other half.

Targets and initial overlap distractor words shared at least the onset and nucleus of the initial syllable; targets and final overlap distractor words shared at least the nucleus and coda of the final syllable. The mean number of shared initial segments was 2.28 (range 2–5), and the mean number of shared final segments was 3 (range 2–5). A total of 24 of the initial and 28 of the end overlap distractors had the same stress placement as the target name. Distractor words had a mean frequency of 41.7 (range 0–197) and 54.4 (range 0–510) occurrences per million in the initial and final overlap conditions, respectively. The stimuli used are listed in Appendix B.

Procedure and design

The experimental procedure was identical to that of Experiment 1. The session consisted of 288 trials, subdivided into four experimental blocks, which were separated by short breaks. The entire experiment lasted approximately 30 minutes. Each picture was presented two times in each condition. The experimental design included the two levels within-subjects factors initial segmental overlap (present, absent) and final segmental overlap (present, absent).

Results

Mean RTs, standard errors of the means, and mean percentages of errors in the four conditions are presented in Table 2. For the total number of excluded trials per condition see Table 2. A repeated measures analysis of variance (ANOVA) with the factors initial segmental overlap (present vs. absent) and final segmental overlap (present vs. absent), performed with both participants (F_1) and items (F_2) as random variables, yielded main effects of initial segmental overlap, $F_1(1, 23) = 20.18$, $p < .001$, $MSE = 319.49$; $F_2(1, 35) = 6.09$, $p < .05$, $MSE = 1{,}450.2$, and final segmental overlap, $F_1(1, 23) = 57.1$, $p < .001$, $MSE = 159.1$; $F_2(1, 35) = 17.8$, $p < .001$, $MSE = 855.2$. The interaction between initial and final segmental overlap was only marginally significant in the by-subjects analysis, $F_1(1, 23) = 3.3$, $p = .08$, $MSE = 194.9$, and nonsignificant in the by-items analysis, $F_2(1, 35) = 1.03$, $p > .05$.

Table 2. *Mean reaction times, standard errors of means, error percentages, and percentage of trials excluded from the analysis for Experiment 2*

	RT	*SE*	*Errors*	*Excluded*
Initial overlap	728	12.2	2.6	5.7
Final overlap	725	11.0	1.7	4.6
Combined overlap	703	13.1	1.9	5.0
Combined unrelated	739	12.2	2.7	5.9

Additional contrasts were conducted between the unrelated condition and the three types of phonologically related conditions. Significant phonological facilitation was found in the condition with combined initial and final segmental overlap, $M\text{diff} = 35.8$ ms, $F_1(1, 23) = 48.2$, $p < .001$; $M\text{diff} = 36.2$ ms, $F_2(1, 35) = 23.6$, $p < .001$. There was also significant facilitation for the condition with only initial overlap in the participant analysis, $M\text{diff} = 11.2$ ms, $F_1(1, 23) = 5.5$, $p < .05$, but not in the items analysis ($F < 1.2$), and for the condition with only final overlap, $M\text{diff} = 14.2$ ms, $F_1(1, 23) = 13.1$, $p < .001$; $M\text{diff} = 15.3$ ms, $F_2(1, 35) = 4.4$, $p < .05$.

Most importantly, separate post hoc comparisons revealed that, whereas RTs did not differ between the single conditions providing either initial or final overlap (ts < 0.6), the effect of phonological facilitation was strongly enhanced when the word pairs provided a combined overlap of initial and final segments, $M\text{diff} = 24.6$ ms, $t_1(23) = 6.6$, $p < .001$; $M\text{diff} = 25.8$ ms, $t_2(35) = 3.7$, $p < .01$, for the comparison with the single condition with initial overlap, and *M*diff = 21.5 ms, $t_1(23) = 4.7$, $p < .001$; *M*diff = 20.8 ms, $t_2(35) = 3.0$, $p < .01$, for the comparison with the single condition with final overlap.

The error rates in this experiment were low, 2.2% on average, and did not vary systematically with the differences in response latencies between conditions (cf. Table 2). Therefore, no further error analysis was performed.

Discussion

This experiment investigated whether the presentation of multiple phonologically related words induces stronger facilitation in a typical picture–word interference situation. The results can be summarized rather straightforwardly. The magnitude of phonological facilitation can be boosted considerably by presenting multiple words with nonredundant phonological relationships to the target picture name (e.g., a combination of initial and final segmental overlap). In fact, the facilitation induced by multiple words was as strong as expected when both words contribute in a more or less additive fashion. However, considering that the conclusion of additivity would be based on a zero effect—that is, the missing interaction between the two distractor types—and taking into account that this interaction reached marginal significance in the subjects analysis ($p = .08$), the present data are clearly not sufficient to draw any conclusions in terms of strict additivity or interaction. Additive or not, for the present purpose of enhancing the chances to detect concurrent word form activation by magnifying phonological effects, it is sufficient to show a boost of phonological facilitation, which we clearly do. Whether or not the facilitation induced by the combined presentation of two related words is precisely the sum of the two distractor effects in isolation is not directly relevant here because it would not alter the predictions derived for discrete and cascading models in a substantial way. For a more extensive discussion of interactions between different distractor types using multiple distractors, see Melinger and Abdel Rahman, 2004.

To summarize, the possibility of boosting the effects of phonologically related distractor words provides a means of reinvestigating concurrent phonological activation in the picture–word interference paradigm, for which it has been argued that the respective effects might not be strong enough to be detected with this experimental paradigm (Dell & O'Seaghdha, 1991, 1992; O'Seaghdha & Marin, 1997). This was done in the following two experiments.

EXPERIMENT 3

Here, we used multiple phonologically related words to test whether we can find any evidence for the phonological activation of potential semantic alternatives of the target utterance. Because Experiment 2 has shown that the effect of phonologically related words can be enhanced by the presentation of multiple complementary related words, the chances for observing traces of concurrent phonological activation should be enhanced as well. To test whether such traces can be found, we presented distractor word pairs simultaneously with a target picture, which was either directly phonologically related to the distractors (e.g., target picture: dolphin, Dutch: Dolfijn; distractors: Dokter, Mandarijn) or indirectly phonologically related via a semantic categorically related competitor (e.g., target picture: shark, Dutch: Haai; distractors: Dokter, Mandarijn, phonologically related to the competitor Dolfijn). Thus, we constructed a second set of pictures such that the pictures of the first set presented in Experiment 2 and their respective counterparts in the second set represented potential semantic competitors that are assumed to be active during naming.

For the first set of pictures, which are directly related to the distractor words, we expected to replicate the facilitation observed in Experiment 2. The critical question was whether the same words have any influence on the naming latencies of the counterpart pictures. In short, does the phonological relatedness of the words to a semantic competitor alter the naming latencies, as would be expected from models assuming continuous transmission of activation, or is there no sign of mediated phonological effects, as would be expected from a discrete point of view? Based on earlier findings we expect that indirect phonologically related words should, if they affect naming latencies, hamper target naming. For example, Jescheniak and Schriefers (1998) observed slower naming latencies when words were presented that were phonologically related to a synonym. Theoretically, there are two potential loci for this effect. Interference could be due to competition between word form representations. A word form level locus could be realized either as competition between active segments or whole word form representations of the target and competitor (Caramazza, 1997; La Heij, 1988; Starreveld & La Heij, 1995, 1996) or between active syllable representations needed to phonetically encode the target and competitor (Roelofs, 1997). However, while theoretically feasible, there is to our knowledge no direct empirical evidence for interference effects between segments. Alternatively, as suggested by Dell and O'Seaghdha (1991) the effect could arise due to feedback from the word form to the lemma of the target's active competitor. It is assumed here that picture naming includes the coactivation of lexical competitors, which in turn feed back to their lemma node, thus producing stronger competition at the lemma level. Both options are theoretically conceivable, and in both cases the word forms of semantic alternatives are active.

Method

Participants

A total of 24 adult Dutch native speakers from the Max Planck Institute for Psycholinguistics subject pool were paid for their participation in the experiment. All participants reported normal or corrected-to-normal visual acuity and normal colour vision. None of the participants took part in the previous experiments.

Stimuli

The target pictures were the same as those presented in Experiment 2. In addition, a second set of 36 pictures was created such that for each picture of the original set there was a semantically related but phonologically unrelated counterpart (for example, the counterpart for the target picture Dolfijn was the picture of a shark, Dutch: Haai; see Appendix C). The mean frequency of target picture names was 35 (range 0–300) for the first, directly related, set and 17 (range 0–247) for the second, indirectly related, set.

All pictures were presented together with two different types of distractor pairs. With respect to the original set of pictures these word pairs consisted of either two phonologically related words with initial and final overlap, or two unrelated words. The unrelated word pairs were constructed by recombining single phonologically related words from other pictures such that, depending on the presented target picture, each word could be phonologically related or unrelated. However, the pairing of distractor words in the related and unrelated condition was not matched (cf. Appendix C). The identical distractor pairs were also presented simultaneously with the respective counterpart pictures (e.g., Haai), therefore being either phonologically related to the semantic competitor (Dolfijn) of the target picture name or unrelated. For each condition, two different word pairs were presented; one pair was gender congruent to the target, and one pair was gender incongruent.[6] Distractor words had a mean frequency of 34 (range 0–544) and 66 (range 0–1526) occurrences per million in the initial and final overlap conditions, respectively. Phonological overlap was defined as before, with eight exceptional cases. The mean number of shared initial segments was 2.37 (range 2–6), and that of shared final segments was 2.65 (range 1–6). A total of 47 of the 72 distractor words had the same stress placement as the target name.

[6] Because earlier unpublished experiments with a similar design have shown that the effects are less stable when only one distractor pair was presented we sought to increase statistical power by introducing two different distractor pairs for each picture and condition.

As in the previous experiment the relative position of the related words was counterbalanced between pictures such that half of the words with initial segmental overlap were presented in the upper position, and half were presented in the lower position. All other details of stimulus presentation were identical to those in Experiment 1.

Procedure and design

The experimental procedure was identical to that of Experiment 2. The session consisted of 576 trials, subdivided into four experimental blocks, which were separated by short breaks. Each picture was presented four times in each condition. The entire experiment lasted approximately 45 minutes. The design included the within-subjects factor target (direct phonological relation to the distractors vs. indirect relation via a semantic competitor), and relatedness (phonologically related or unrelated).

Results

Table 3 displays the mean reaction times and mean percentages of errors as a function of condition. For the total number of excluded trials based on the criteria described in Experiment 1, see Table 3. ANOVA yielded a main effect of target, reflecting that the original target pictures were named significantly faster than their respective counterparts, $F_1(1, 23) = 119.7$, $p < .001$, $MSE = 565.36$; $F_2(1, 70) = 8.5$, $p < .01$, $MSE = 6,909.17$. The factor relatedness reached significance in the participants analysis, $F_1(1, 23) = 6.3$, $p < .05$, $MSE = 191.29$, but not in the item analysis, $F_2(1, 70) < 1$, whereas there was a highly robust interaction between target type and relatedness both in the participants and in the items analysis, $F_1(1, 23) = 48.39$, $p < .001$, $MSE = 317.44$; $F_2(1, 70) = 14.3$, $p < .001$.

Separate comparisons revealed that the observed interaction was due to opposing effects of phonologically related distractor pairs on the two types of target pictures. Compared with the unrelated condition, naming latencies were faster when pictures and words were directly phonologically related, $M\text{diff} = -32.3$ ms, $t_1(23) = -6.1$, $p < .001$; $M\text{diff} = -31.9$ ms, $t_2(35) = -3.4$, $p < .01$, whereas, most importantly, they were slower when picture and words were indirectly phonologically related via a semantic competitor, $M\text{diff} = 18.2$ ms, $t_1(23) = 4.7$, $p < .001$; $M\text{diff} = 20.3$ ms, $t_2(35) = 1.9$, $p = .054$.

The error rates were low (under 5% on average) and mirrored the pattern of the reaction times. Therefore, a speed–accuracy trade-off can be ruled out.

Discussion

As expected, we replicated the phonological facilitation for the directly related target pictures. For the pictures with an indirect phonological

Table 3. *Mean reaction times, standard errors of means, error percentages, and percentage of trials excluded from the analysis for Experiments 3 and 4*

Experiment	*Distractor conditions*		*RT*	*SE*	*Errors*	*Excluded*
3	Directly related	Combined overlap	795	15.8	3.1	5.5
		Combined unrelated	827	14.8	3.2	5.3
	Indirectly related	Combined overlap	873	15.3	6.0	7.5
		Combined unrelated	855	14.8	4.3	5.1
4	Directly related	Combined overlap	780	18.5	1.7	5.4
		Combined unrelated	818	17.9	2.1	5.2
	Indirectly related	Combined overlap	855	17.6	2.8	6.5
		Combined unrelated	839	17.2	2.0	5.0

Note: RT = mean reaction times (in ms). *SE* = standard errors.

relationship to the words via a semantic competitor, we found this effect to be reversed. The naming latencies for these targets were slower than those in the unrelated condition. Whether this interference reflects competition at the word form level or feedback-induced enhanced competition at the lemma level cannot be distinguished on the basis of the present data. According to both accounts this finding can be interpreted in terms of mediated phonological interference, either due to competition between the target and competitor word forms or due to stronger lemma competition, induced by feedback from the competitor's word form.

However, before drawing strong conclusions as to the specific locus of this effect, a potential alternative explanation needs to be discussed, which is related to the, rather atypical, presentation of multiple words. One consequence of this double stimulation is that at least some of the phonologically related words pairs included the entire target (or competitor) name. In contrast, because the single related words were recombined for the construction of the unrelated word pairs, it is unlikely that the two words in this condition also combine to create an existing word. Thus, the related conditions and the control condition differ not only in their relationship to the target picture but also in that the former potentially provides an additional existing word whereas the latter does not. Since the presentation of a word as compared to control conditions such as a row of *x*s alters the naming process, this difference between the related and unrelated condition might explain the observed interference effect. Experiment 4 was designed to further examine this issue with a matching unrelated condition.

EXPERIMENT 4

The aim of this experiment was to test whether the findings of Experiment 3 can be replicated when identical word pairs are presented in the related and unrelated conditions. For this purpose we simply reassigned related word pairs to different pictures in order to create the unrelated condition.

Method

Participants

A total of 24 adult Dutch native speakers from the Max Planck Institute for Psycholinguistics subject pool were paid for their participation in the experiment. All participants reported normal or corrected-to-normal visual acuity and normal colour vision. None of the participants took part in the previous experiments. The data of one participant were excluded and replaced because of a high error rate.

Stimuli, procedure, and design

The stimuli were identical to those presented in Experiment 3 except that the phonologically related word pairs were not recombined for the construction of the unrelated condition, but instead were reassigned to different pictures as a pair (cf. Appendix D). All other details of stimulus presentation, procedure, and design were the same as those described in Experiment 3.

Results

Table 3 displays the mean reaction times and mean percentages of errors as a function of condition. For the total number of excluded trials based on the criteria described in Experiment 1, see Table 3. As in Experiment 3, ANOVA yielded a main effect of target, showing again that the original target pictures were named significantly faster than their respective counterparts, $F_1(1, 23) = 105.5$, $p < .001$, $MSE = 532.62$; $F_2(1, 70) = 10.9$, $p < .001$, $MSE = 4{,}319.91$. There was a main effect of relatedness, $F_1(1, 23) = 15.15$, $p < .001$, $MSE = 205.10$, and $F_2(1, 70) = 4.47$, $p < .05$, $MSE = 903.87$, and a significant interaction between target type and relatedness both in the participants analysis as well as in the items analysis, $F_1(1, 23) = 43.02$, $p < .001$, $MSE = 399.97$; $F_2(1, 70) = 29.47$, $p < .001$.

Separate comparisons revealed a similar pattern of results as the one obtained in Experiment 3—namely, opposing effects of phonologically related distractor pairs on the two types of target pictures. Again we observed that, as compared to the unrelated condition, direct phonological relatedness facilitated picture naming, *M*diff $= -38.1$ ms, $t_1(23) = -6.4$, $p <$ .001; *M*diff $= -37.8$ ms, $t_2(35) = -6.0$, $p < .001$, whereas an indirect phonological relationship with a lexical competitor hampered target picture naming, *M*diff $= 15.4$ ms, $t_1(23) = 3.9$, $p < .001$; *M*diff $= 16.6$ ms, $t_2(35) = 2.1$, $p = .05$. Thus, we successfully replicated the result pattern of Experiment 3 even when the word pairs did not differ between the related and unrelated conditions.

GENERAL DISCUSSION

In a series of picture–word interference experiments we tested whether any evidence for the activation of categorically related lexical candidates at the level of the word form can be found when the chances for detecting such effects are enhanced. For this purpose, we extended the classic PWI by presenting multiple distractor words with the same relationship to the target picture. The findings of Experiment 1 demonstrate that the classic effects of semantic interference and phonological facilitation can also be obtained when multiple words are presented. Furthermore, they indicate that the effects can be boosted significantly, provided that the combined distractor words introduce complementary facets of the same type of information. For instance, in order to boost semantic interference effects it is not sufficient to present an identical word twice, nor is it sufficient to present a phonologically related distractor pair with overlapping, and thus redundant, phonological information. Accordingly, the *literal* presentation of more of the same does not noticeably influence the magnitude of the respective effect, whereas the *complementary* presentation of more of the same type of information (for instance, two different semantically related words) results in more of the same effect. Furthermore, Experiment 1 demonstrates that multiple distractor effects are located within the speech production system, rather than affecting more nonspecific information processing components or simple enhanced distractor detection (cf. Discussion of Experiment 1). Thus, the results of this experiment show that the multiple distractor method offers new possibilities to investigate speech production processes—for instance, as shown here, by magnifying classic distractor effects. Alternatively, this method can be used for the combined presentation of mixed word pairs, thus allowing for an investigation of interactions between different types of distractors (Melinger & Abdel Rahman, 2004).

Experiment 2 demonstrated that phonological facilitation can be enhanced considerably by presenting multiple related words with overlapping initial and final segments to the target picture name. This technique was used to test for the word form activation of categorically related alternatives in Experiments 3 and 4. In Experiment 4 we successfully replicated the result pattern of Experiment 3 even when the word pairs did not differ between the related and unrelated conditions, as they did in Experiment 3. Therefore, the observed interference effects are unlikely to be caused by the extraction of an existing word from the distractor pairs per se. The results of the two experiments are remarkably similar, each demonstrating that naming latencies were affected by distractor words with a phonological relationship to a nontarget semantic alternative. Therefore, the current findings support the assumption of continuous information transmission from lemmas to word forms. As discussed before, this effect could be caused by interference between word form representations (their component segments or syllables) or, alternatively, due to enhanced lemma competition via feedback from the word form to the competing lemma.

However, deriving predictions for the effects of multiple distractor words is more complex and thus potentially more error prone than deriving predictions for single distractors. Due to possible interactions between the presented words, and interactions between the processing of two words and a picture simultaneously, alternative scenarios are conceivable. For instance, the simultaneous presentation of two words with initial and final segmental overlap might have enabled the participants to directly extract the target or competitor name because the related words combine to create the respective name at least in some cases (e.g., the word *piano* can be extracted from the distractor words Pistole, Kano). In comparison to the unrelated condition, this should clearly facilitate the naming of the directly related target pictures. With respect to the indirectly related pictures (for example, organ; Dutch: Orgel) the same distractor words would simply combine to form the semantic competitor *piano*, thereby directly activating the competitor lemma. Since semantic category members are well known to induce slower naming latencies, it would not be all that surprising to find such an effect. Consequently, the finding of slower reaction times in this condition would simply reflect a semantic interference effect and would therefore not bear on the issue of concurrent phonological activation.

As a precaution against such a strategy we balanced the relative position of the related words such that words with initial segmental overlap were presented in the upper position for half the pictures and in the lower position for the other half. Furthermore, according to this scenario any inhibitory effects should be reduced or even absent when the competitor name cannot be extracted directly from the two words (target word: hammer; distractors: hart and water). Post hoc comparisons in Experiment 4 (by participants) with a subset of the pictures whose names could not be extracted from the distractor pairs (31 of 72 pictures) revealed that the directly induced facilitation, $M\text{diff} = -41.4$ ms, $t(23) = -5.9$, $p < .001$, relative to the control condition, as well as the indirectly induced inhibition, $M\text{diff} = 53$ ms, $t(23) = 8.8$, $p < .001$, was preserved. In fact, the numerical difference between the indirectly related and unrelated conditions was even bigger than the difference across all target pictures. This finding is at variance with the above prediction, rendering it unlikely that the present data simply reflect directly induced semantic interference.

Another concern is related to the specific design of Experiments 3 and 4. Both experiments were designed such that the semantic alternatives of the target pictures were parts of the response set. That is, the word form of a semantic competitor in a given trial was the target utterance in other trials of the experiments. Because the pictures were presented repeatedly in all experiments (two times in each condition), and the number of tokens drawn from the six different semantic categories was comparatively small, some category members of the target pictures might have become chronically activated during the experiments. This preactivation of alternatives, together with the presentation of two words sharing initial and final segments with the target or competitor name, might have contributed to the observed effects. In other words, there were multiple cues providing converging indications of a possible picture name: the potential preactivated competitor, one word sharing initial segments and one word sharing final segments with the competitor. Since the influence of competitor preactivation in the current experiments is difficult to estimate, we cannot rule out this concern. Multiple distractor presentation is a new method, and, clearly, more work is needed on the precise mechanisms of this method.

However, a comparison between the phonological facilitation effects for directly related targets in Experiments 3 and 4 with the respective effects observed in Experiment 2 should yield some indication as to whether the influence of chronic competitor activation is strong. This effect not only should hold for targets with an indirect phonological relation to the distractor words but should be equally strong also for targets with a direct relation to the words. Therefore, if design-induced competitor activation affects naming latencies, the phonological facilitation effects should be reduced in Experiments 3 and 4 (where the competitor was part of the response set) as compared to Experiment 2 (where only directly related pictures and words were presented). Numerically, phonological facilitation does not seem to differ systematically across the experiments. In Experiment 2 we observed facilitation of about 36 ms, in Experiment 3 about 32 ms, and in Experiment 4 about 38 ms on average. Thus, competitor preactivation as such does not seem to be a major determinant of the current effects, although we cannot entirely exclude the possibility that it prepared the ground for the effects of multiple distractors.

At a more general level, a comparison with previously reported failures to find evidence for phonological coactivation of ordinary category members in the picture–word interference task raises the question of why we have found effects which have not been observed when only one distractor word was presented. Our line of reasoning was that we have boosted the respective effects and by doing so have increased the chances of detecting phonological activation of nontargets. This assumption was supported by Experiment 2 where the magnitude of phonological facilitation was boosted by presenting multiple related words as compared to presenting only a single related word. Nevertheless, even the boosted effect in this experiment, observed at about 36 ms, was not particularly large. A comparison with other reports on the effects of single phonologically related words suggests that it is rather unlikely that the numerical size of the effect can explain the difference between our results and previously reported failures to find such effects. For example, Schriefers and colleagues (1990) obtained facilitation of 50 ms from auditorily presented phonologically related words relative to an unrelated control. Thus, rather than the effects being dependent on the magnitude of the priming effect, our account is that the presentation of overlapping initial and final segments activates a greater proportion of the alternative word form, not just a few segments more strongly. Therefore, the current findings can be most easily accounted for by assuming that, during picture naming, semantic category members are activated up to and including the level of the word form. This is in line with cascading models that include feedback from the word forms to the lemma level and with models assuming unidirectional spread of activation from lemmas to word forms.

Since category members can hardly be viewed as appropriate naming alternatives in a given context, the present results cannot be accounted for with the assumption of multiple lemma selection. This interpretation is in line with two recent findings. Hantsch (2003) observed slower picture naming latencies when distractor words were phonologically related to the subordinate or superordinate name (e.g., produced picture name: fish; distractor word: car, phonologically related to the subordinate carp, or vice versa: produced picture name: carp; distractor word: film, phonologically related to the superordinate fish). Crucially, contextual appropriateness did not alter this result pattern. For example, when the target picture was accompanied by a second picture from the same category (e.g., target picture depicted a carp, second picture depicted a catfish) the category name fish is a contextually inappropriate naming response because it cannot distinguish between the two pictures. Nevertheless, producing the name carp was affected by the presentation of a word that was phonologically related to the—contextually inappropriate—alternative name fish. Interestingly, in Hantsch's study the alternative names (e.g., fish) were never targets as they were in the current Experiments 3 and 4. This further suggests that competition is not restricted to the (chronically active) set of target words in an experiment (Caramazza & Costa, 2000).

A recent study on elicited intrusion errors in picture naming (Ferreira & Griffin, 2003) presented an elegant demonstration of phonological influences on speech planning. Participants were presented with cloze sentences and a picture to be named—for example, a priest. When the sentence primed a homophone of a semantic competitor (for example, none, phonologically identical to nun) participants were more likely to substitute the respective target name with the semantic competitor than they were when an unrelated word was primed. These findings, in line with the results presented here, suggest that even the word forms of contextually inappropriate competitors (e.g., calling a priest a nun) are phonologically activated.

Throughout this article we have been assuming that semantic interference effects arise at the lemma level, rather than the conceptual (Costa, Mahon, Savova, & Caramazza, 2003; Glaser & Düngelhoff, 1984) or word form level (Glaser & Glaser, 1989; La Heij, 1988; Starreveld & La Heij, 1995). Accordingly, our theoretical discussion has focused on theories that incorporate a lemma level. The respective models provide an explicit account for the current issue, which allowed us to inherit the predictions used in previous investigations of concurrent nontarget word form activation. We now turn to a discussion on how to interpret our data in the context of alternative models proposing a spread of activation from concepts to their respective word forms (Caramazza, 1997). The latter models locate competition for selection at the word form level, thus predicting concurrent word form activation of nontarget names. In this respect, these alternative models are consistent with the results presented in Experiments 3 and 4. Having said this, however, these models do not necessarily predict that traces of concurrent phonological activation should be weak and thus difficult to detect. Without an intermediate representation between concepts and word forms, there is no mechanism to restrict the flow of activation to phonologically related competitors. Thus, one would expect strong and easily detectable traces of concurrent phonological activation. Rather, models with limited continuous transmission of activation between concepts and nontarget word forms (via an intermediate lemma representation) can more easily explain why evidence of concurrent word form activation is only observed when semantic or phonological overlap is maximized. Recently, Roelofs (2003) demonstrated that "functional discreteness" could be maintained within the WEAVER++ model, which included limited continuous transmission within the architecture. Whether functionally discrete models of this sort strike the right balance needed to capture the accruing evidence for concurrent word form activation is an open question.

Thus, given an increasing number of recent findings on the question of concurrent word form activation in speech production including the present observations, the evidence in favour of cascading models assuming continuous transmission from lemmas (or concepts) to word forms seems to be cumulating. Having said this, however, these same findings demonstrate that one needs to work hard to find such effects, either by maximizing semantic overlap between targets and distractors (e.g., utilizing synonyms or cognates) or, as demonstrated here, by maximizing phonological overlap (utilizing multiple distractor word presentation). Phonological coactivation appears to be present to a measurable extent mainly in situations in which the production system is particularly vulnerable in the sense of enhanced susceptibility to distracting stimuli. This could be caused by the presence of multiple distractor words or the presence of single distractors with a phonological relation to a particularly strong competitor. In line with these assumptions, Jescheniak and colleagues (2006) have observed phonological coactivation in children, using a classic PWI paradigm with single distractors related to ordinary category members. The authors show that these effects decrease with age, being absent in adults. Furthermore, children appear to be generally more susceptible to different types of distractors, showing larger effects than adults. Together, these findings suggest that in the slower, less proficient, or stimulation-induced susceptible production system, lexical coactivation does occur.

In conclusion, the current findings show that multiple distractor presentation can be used, and offers new possibilities, for investigating the microstructure of single-word production. Furthermore, they suggest that the failure to detect traces of concurrent phonological activation in the classic picture–word interference paradigm might indeed be due to the subtlety of the respective effects. The simple presentation of "more of the same" induced indirect effects of words that are phonologically related to a competitor of the planned utterance, a finding consistent with theories assuming moderate concurrent word form activation of related nontargets.

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REFERENCES

Bloem, I., & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language*, *48*, 468–488.

Bloem, I., van den Boogaard, S., & La Heij, W. (2004). Semantic facilitation and semantic interference in language production: Further evidence for the conceptual selection model of lexical access *Journal of Memory and Language*, *51*, 307–323.

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology*, *14*, 177–208.

Caramazza, A., & Costa, A. (2000). The semantic interference effect in the picture–word interference paradigm: Does the response set matter? *Cognition*, *75*, 51–64.

Costa, A., Caramazza, A., & Sebastian-Galles, N. (2000). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 1283–1296.

Costa, A., Mahon, B., Savova, V., & Caramazza, A. (2003). Level of categorisation effect: A novel effect in the picture–word interference paradigm. *Language and Cognitive Processes*, *18*, 205–233.

Cutting, C. J., & Ferreira, V. S. (1999). Semantic and phonological information flow in the production lexicon. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*, 318–344.

Damian, M. F., & Martin, R. C. (1999). Semantic and phonological factors interact in single word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*, 345–361.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, *93*, 283–321.

Dell, G. S., & O'Seaghdha, P. G. (1991). Mediated and convergent lexical priming in language production: A comment on Levelt et al. (1991). *Psychological Review*, *98*, 604–614.

Dell, G. S., & O'Seaghdha, P. G. (1992). Stages of lexical access in language production. *Cognition*, *42*, 287–314.

Ferreira, V. S., & Griffin, Z. M. (2003). Phonological influences on lexical (mis)selection. *Psychological Science*, *14*, 86–90.

Glaser, W. R., & Düngelhoff, F. J. (1984). The time course of picture-word interference. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 640–654.

Glaser, W. R., & Glaser, M. O. (1989). Context effects in Stroop-like word and picture processing. *Journal of Experimental Psychology: General*, *118*(1), 13–42.

Hantsch, A. (2003). Fisch oder Karpfen? Lexikale Aktivierung von Benennungsalternativen bei der Objektbenennung [Fish or carp? Lexical activation of alternatives in object naming]. *MPI series in cognitive neuroscience*, *40*. Leipzig: Max Planck Institut für neuropsychologische Forschung.

Humphreys, G. W., Riddoch, M. J., & Quinlan, P. T. (1988). Cascade processes in picture identification. *Cognitive Neuropsychology*, *5*, 67–103.

Huynh, H., & Feldt, L. S. (1976). Estimation of the box correction for degrees of freedom from sample data in the randomised block and split-plot design. *Journal of Educational Statistics*, *1*, 69–82.

Jescheniak, J. D., Hahne, A., Hoffmann, S., & Wagner, V. (2006). Phonological activation of category coordinates during speech planning is observable in children but not in adults: Evidence for cascaded processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*, 373–386.

Jescheniak, J. D., Hahne, A., & Schriefers, H. (2003). Information flow in the mental lexical during speech planning: Evidence from event-related brain potentials. *Cognitive Brain Research*, *15*, 261–276.

Jescheniak, J. D., & Schriefers, H. (1998). Serial discrete versus cascaded processing in lexical access in speech production: Further evidence from the co-activation of near-synonyms. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 1256–1274.

Kempen, G., & Huijbers, P. (1983). The lexicalisation process in sentence production and naming: Indirect election of words. *Cognition*, *14*, 185–209.

La Heij, W. (1988). Components of Stroop-like interference in picture naming. *Memory and Cognition*, *16*, 400–410.

Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. Cambridge, MA: MIT Press.

Levelt, W. J. M. (1999). Models of word production. *Trends in Cognitive Sciences*, *3*, 223–232.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*, 1–38.

Levelt, W. J. M., Schriefers, H., Vorberg, D., Meyer, A. S., Pechmann, T., & Havinga, J. (1991). The time course of lexical access in speech production: A study of picture naming. *Psychological Review*, *98*, 122–142.

Lupker, S. J. (1979). The semantic nature of response competition in the picture-word interference task. *Memory and Cognition*, *7*, 485–495.

Melinger, A., & Abdel Rahman, R. (2004). Investigating the interplay between semantic and phonological distractor effects in picture naming. *Brain and Language*, *90*, 213–220.

Morsella, E., & Miozzo, M. (2002). Evidence for a cascade model of lexical access in speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 555–563.

O'Seaghdha, P. G., & Marin, J. W. (1997). Mediated semantic-phonological priming: Calling distant relatives. *Journal of Memory and Language*, *36*, 226–252.

Peterson, R. R., & Savoy, P. (1998). Lexical selection and phonological encoding during language production: Evidence for cascaded processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 539–557.

Rapp, B., & Goldrick, M. (2000). Discreteness and interactivity in spoken word production. *Psychological Review*, *107*, 460–499.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*, 107–142.

Roelofs, A. (1997). The WEAVER model of word-form encoding in speech production. *Cognition*, *64*, 249–284.

Roelofs, A. (2003). Goal-referenced selection of verbal action: Modeling attentional control in the Stroop task. *Psychological Review*, *110*, 88–125.

Schriefers, H., Meyer, A. S., & Levelt, W. J. M. (1990). Exploring the time course of lexical access in production: Picture–word interference studies. *Journal of Memory and Language*, *29*, 86–102.

Schriefers, H. J., Teruel, E., & Meinshausen, R. M. (1998). Producing simple sentences: Results from picture word interference experiments. *Journal of Memory and Language*, *39*, 609–632.

Starreveld, P., & La Heij, W. (1995). Semantic interference, orthographic facilitation, and their interaction in naming tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 686–698.

Starreveld, P., & La Heij, W. (1996). Time-course analysis of semantic and orthographic context effects in picture naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *22*, 896–918.

APPENDIX A

Stimuli used in Experiment 1

The upper word in each cell is the single distractor word that was combined with a row of *x*s for Group A and was presented twice for Group B. The bottom word in each cell is the second word presented in each respective double condition.

Picture name *Translation*	*Single semantic* *Second semantic*	*Single phonological* *Second phonological*	*Single unrelated* *Second unrelated*
beer *beer*	hond konijn	beeld beker	harp venkel
hond *dog*	konijn beer	horloge hok	pak bed
schildpad *turtle*	dolfijn kat	schilderij schip	hark rok
dolfijn *dolphin*	kat schildpad	dokter dobber	stoel schaar
konijn *rabbit*	schildpad hond	koning komeet	bekkens venkel
kat *cat*	beer dolfijn	kasteel kabouter	pak radijs
bed *bed*	kast tafel	bel berg	asperge kat
bank *couch*	wieg stoel	bakker ballon	konijn piano
tafel *table*	stoel bed	taart taco	baco vest
wieg *cradle*	bank kast	wiel wiek	das hamer
kast *wardrobe*	bed wieg	kam kado	beer wortel
stoel *chair*	tafel bank	stoep stoer	banjo hark
harp *harp*	banjo tambourijn	hart hand	komkommer beer
piano *piano*	tambourijn bekkens	pistool piraat	boor tafel
viool *violin*	bekkens harp	vinger videoband	hemd sok

(*Continued overleaf*)

Appendix A (Continued)

Picture name *Translation*	*Single semantic* *Second semantic*	*Single phonological* *Second phonological*	*Single unrelated* *Second unrelated*
tamborijn *tambourine*	piano banjo	tand tak	hond zaag
banjo *banjo*	harp viool	banaan bal	kast tomaat
bekken *cymbals*	viool piano	benzinepomp bes	tafel pak
rok *skirt*	das hemd	rolstoel rots	tomaat hond
vest *vest*	sok pak	verf ventiel	kat bank
sok *sock*	hemd vest	soldaat sorbet	zaag viool
hemd *undershirt*	pak rok	helm heks	radijs boor
das *tie*	vest sok	dak dartbord	wieg asperge
pak *suit*	rok das	passer parachute	tamborijn stoel
schaar *scissors*	hamer boor	schaal schaats	harp dolfijn
hamer *hammer*	boor zaag	haai haan	sok wieg
zaag *saw*	hark baco	zadel zakenman	bed tambourijn
boor *drill*	zaag hark	boom boot	wortel hemd
baco *wrench*	schaar hamer	baard baan	dolfijn komkommer
hark *rake*	baco schaar	harnas hals	viool konijn
radijs *radish*	tomaat wortel	raket ramp	piano schildpad
komkomer *cucumber*	venkel tomaat	koffer kok	schildpad baco
venkel *fennel*	asperge komkommer	vergiet ventilator	schaar bekkens

APPENDIX B

Stimuli used in Experiment 2

Picture name *Translation*	*Initial overlap* *Unrelated*	*Final overlap* *Unrelated*	*Unrelated* *Unrelated*	*Initial overlap* *Final overlap*
beer *beer*	beeld vergiet	speer hak	vergiet hak	beeld speer
hond *dog*	horloge koffer	mond ivoor	koffer ivoor	horloge mond
schildpad *turtle*	schilderij asbak	handvat kano	asbak kano	schilderij handvat
dolfijn *dolphin*	dokter tovenaar	mandarijn poel	tovenaar poel	dokter mandarijn
konijn *rabbit*	koning wolk	azijn tak	wolk tak	koning azijn
kat *cat*	kasteel schaal	vat kaart	schaal kaart	kasteel vat
bed *bed*	bel harnas	fret speer	harnas speer	bel fret
bank *couch*	bakker rolstoel	drank mortel	rolstoel mortel	bakker drank
tafel *table*	taart boom	wafel paar	boom paar	taart wafel
wieg *cradle*	wiel zadel	vlieg handvat	zadel handvat	wiel vlieg
kast *wardrobe*	kam haai	bast enkel	haai enkel	kam bast
stoel *chair*	stoep raket	poel kwark	raket kwark	stoep poel
hoorn *horn*	hoop passer	doorn mandarijn	passer mandarijn	hoop doorn
piano *piano*	pistool dak	kano bijtel	dak bijtel	pistool kano
viool *violin*	vinger helm	gladiool congierge	helm congierge	vinger gladiool
tamborijn *tambourine*	tand soldaat	komijn zomer	soldaat zomer	tand komijn
banjo *banjo*	banaan verf	jojo remt	verf remt	banaan jojo

(*Continued overleaf*)

Appendix B (Continued)

Picture name *Translation*	*Initial overlap* *Unrelated*	*Final overlap* *Unrelated*	*Unrelated* *Unrelated*	*Initial overlap* *Final overlap*
bekken *cymbals*	bezinepomp baard	hekken vlieg	baard vlieg	benzinepomp hekken
rok *skirt*	rolstoel beeld	stok anijs	beeld anijs	rolstoel stok
vest *vest*	verf horloge	mest hekken	horloge hekken	verf mest
sok *sock*	soldaat dokter	mok jojo	dokter jojo	soldaat mok
hemd *undershirt*	helm lamp	remt straat	lamp straat	helm remt
das *tie*	dak koning	pinpas azijn	koning azijn	dak pinpas
pak *suit*	passer kasteel	hak steen	kasteel steen	passer hak
schaar *scissors*	schaal bel	paar doorn	bel doorn	schaal paar
hamer *hammer*	haai bakker	kamer wafel	bakker wafel	haai kamer
zaag *saw*	zadel tart	maag bast	taart bast	zadel maag
boor *drill*	boom wiel	ivoor mond	wiel mond	boom ivoor
baco *wrench*	baard kam	disco plant	kam plant	baard disco
hark *rake*	harnas stoep	kwark laken	stoep laken	harnas kwark
radijs *radish*	raket hart	anijs maag	hart maag	raket anijs
wortel *carrot*	wolk pistool	mortel disco	pistool disco	wolk mortel
tomaat *tomato*	tovenaar vinger	straat pinpas	vinger pinpas	tovenaar straat
asperge *asparagus*	asbak tand	congierge gladiool	tand gladiool	asbak congierge
komkomer *cucumber*	koffer brief	zomer vat	brief vat	koffer zomer
venkel *fennel*	vergiet bezinepomp	enkel stok	benzinepomp stok	vergiet enkel

APPENDIX C

Stimuli used in Experiment 3

Picture names and translations		*Phonologically related word pairs*			
Target Set 1	*Target Set 2*	*Initial overlap* / *Final overlap*	*Initial overlap* / *Final overlap*	*Unrelated word pairs*	
beer	panda	beker	beeld	vensterbank	hoofd
bear	*panda*	speer	weer	rolstoel	viaduct
hond	wolf	horde	horloge	wikkel	orkest
dog	*wolf*	mond	front	zaal	asfalt
schilpad	krab	schim	schilderij	vinger	credo
turtle	*crab*	mat	handvat	wolk	bot
dolfijn	haai	dokter	doctoraal	jojo	jargon
dolphin	*shark*	mandarijn	festijn	meteoor	pamflet
muis	haas	muilkorf	muntstuk	tand	lek
mouse	*rabbit*	kluis	huis	soldaat	laken
kat	tijger	kaft	kasteel	schim	tafreel
cat	*tiger*	lat	vat	banaan	gevoel
bed	kussen	bestand	bel	dak	rest
bed	*cushion*	visnet	fret	vlonder	straat
bank	sofa	bakker	balkon	muilkorf	front
sofa	*chaise longue*	drank	geschenk	jager	vlas
rek	buro	recept	rest	hart	koopwaar
bookshelf	*desk*	lek	bek	konijn	mond
wieg	box	wikkel	wiel	schaal	harnas
cradle	*playpen*	vlieg	beleg	disco	geschenk
kast	tafel	kam	kalf	bakker	werk
wardrobe	*table*	bast	asbest	dar	venijn
stoel	kruk	stoep	stompje	horde	paar
chair	*stool*	poel	gevoel	baard	anijs
hoorn	trompet	hoop	hoofd	stoep	beleg
horn	*trumpet*	doorn	koren	bel	mandaat
piano	accordeon	picollo	pistool	verf	college
piano	*accordion*	kano	casino	asbak	blok
viool	bas	vinger	viaduct	dokter	horloge
violin	*double bass*	gladiool	riool	haring	sop
tamboerijn	pauken	tand	tafreel	haai	ivoor
tambourine	*timpani*	komijn	venijn	kluis	handvat

(*Continued overleaf*)

Appendix C (Continued)

Picture names and translations		Phonologically related word pairs			
Target Set 1	*Target Set 2*	*Initial overlap Final overlap*	*Initial overlap Final overlap*	*Unrelated word pairs*	
banjo *banjo*	gitaar *guitar*	banaan jojo	banket trio	kaft mest	schilderij vat
bekken *cymbals*	triangle *triangle*	benzine hekken	beslag laken	stok hoop	water vel
rok *skirt*	jurk *dress*	rolstoel stok	ros blok	picollo tovenaar	wonder hotel
vest *vest*	hemd *shirt*	vel orkest	verf mest	casino stompje	doorn kam
sok *sock*	kous *stocking*	soldaat mok	sop hok	beker zomer	festijn beslag
jas *jacket*	bloes *blouse*	jager was	jargon ras	raket komijn	artikel wiel
das *tie*	strik *bowtie*	dar pinpas	dak vlas	mat koffer	asbest toneel
pak *suit*	uniform *uniform*	pamflet dak	passer hak	ras zaad	vlieg kano
schaar *scissors*	grasmaaier *lawnmower*	schaal koopwaar	schaap paar	bast kwark	hok gezag
hamer *hammer*	bijl *axe*	haai kamer	hart water	lat spijs	rio doctoraal
zaag *saw*	vijl *file*	zaal maag	zaad gezag	mandarijjn bek	weer pistool
boor *drill*	schroevedraaier *screwdriver*	boom meteoor	bot ivoor	fret was	riool muntstuk
baco *wrench*	tang *pliers*	baard disco	banket credo	pinpas mortel	ros koren
hark *rake*	schep *shovel*	haring kwark	harnas werk	passer maag	beeld vergiet
radijs *radish*	paprika *pepper*	raket spijs	rad anijs	mok speer	huis visnet
wortel *carrot*	knol *turnip*	wolk mortel	wonder hotel	drank concierge	banket rad
tomaat *tomato*	pompoen *pumpkin*	tovenaar straat	toneel mandaat	kamer poel	dak banket
asperge *asparagus*	prei *leek*	asbak concierge	asfalt college	benzine hak	kasteel kalf

Appendix C (Continued)

Picture names and translations		*Phonologically related word pairs*			
Target Set 1	*Target Set 2*	*Initial overlap* *Final overlap*	*Initial overlap* *Final overlap*	*Unrelated word pairs*	
komkommer *cucumber*	aubergine *eggplant*	koffer zomer	konijn vlonder	enkel gladiool	recept balkon
venkel *fennel*	ui *onion*	vensterbank enkel	vergiet artikel	hekken boom	schaap bestand

APPENDIX D

Stimuli used in Experiment 4

Picture names and translations		*Phonologically related pairs*			
Target Set 1	*Target Set 2*	*Initial overlap* *Final overlap*	*Initial overlap* *Final overlap*	*Unrelated word pairs*	
beer *bear*	panda *panda*	beker speer	beeld weer	raket spijs	rad anijs
hond *dog*	wolf *wolf*	horde mond	horloge front	rolstoel stok	ros blok
schilpad *turtle*	krab *crab*	schim mat	schilderij handvat	horde mond	horloge front
dolfijn *dolphin*	haai *shark*	dokter mandarijn	doctoraal festijn	asbak conciërge	asfalt college
muis *mouse*	haas *rabbit*	muilkorf kluis	muntstuk huis	wolk mortel	wonder hotel
kat *cat*	tijger *tiger*	kaft lat	kasteel vat	vensterbank enkel	vergiet artikel
bed *bed*	kussen *cushion*	bestand visnet	bel fret	vel orkest	verf mest
bank *sofa*	sofa *chaise longue*	bakker drank	balkon geschenk	zaal maag	zaad gezag
rek *bookshelf*	buro *desk*	recept lek	rest bek	pamflet dak	passer hak
wieg *cradle*	box *playpen*	wikkel vlieg	wiel beleg	soldaat mok	sop hok
kast *wardrobe*	tafel *table*	kam bast	kalf asbest	jager was	jargon ras

(*Continued overleaf*)

Appendix D (Continued)

Picture names and translations		*Phonologically related pairs*		*Unrelated word pairs*	
Target Set 1	*Target Set 2*	*Initial overlap* *Final overlap*	*Initial overlap* *Final overlap*		
stoel *chair*	kruk *stool*	stoep poel	stompje gevoel	dar pinpas	dal vlas
hoorn *horn*	trompet *trumpet*	hoop doorn	hoofd koren	schaal koopwaar	schaap paar
piano *piano*	accordeon *accordion*	picollo kano	pistool casino	benzine hekken	beslag laken
viool *violin*	bas *double bass*	vinger gladiool	viaduct riool	koffer zomer	konijn vlonder
tamboerijn *tambourine*	pauken *timpani*	tand komijn	tafreel venijn	boom meteoor	bot ivoor
banjo *banjo*	gitaar *guitar*	banaan jojo	banket trio	muilkorf kluis	muntstuk huis
bekken *cymbals*	triangle *triangle*	benzine hekken	beslag laken	haring kwark	harnas werk
rok *skirt*	jurk *dress*	rolstoel stok	ros blok	kam bast	kalf asbest
vest *vest*	hemd *shirt*	vel orkest	verf mest	bestand visnet	bel fret
sok *sock*	kous *stocking*	soldaat mok	sop hok	wikkel vlieg	wiel beleg
jas *jacket*	bloes *blouse*	jager was	jargon ras	bakker drank	balkon geschenk
das *tie*	strik *bowtie*	dar pinpas	dal vlas	banaan jojo	ballet trio
pak *suit*	uniform *uniform*	pamflet dak	passer hak	recept lek	rest bek
schaar *scissors*	grasmaaier *lawnmower*	schaal koopwaar	schaap paar	hoop doorn	hoofd koren
hamer *hammer*	bijl *axe*	haai kamer	hart water	picollo kano	pistool casino
zaag *saw*	vijl *file*	zaal maag	zaad gezag	kaft lat	kasteel vat
boor *drill*	schroevedraaier *screwdriver*	boom meteoor	bot ivoor	tand komijn	tafereel venijn
baco *wrench*	tang *pliers*	baard disco	banket credo	stoep poel	stompje gevoel

Appendix D (Continued)

Picture names and translations		*Phonologically related pairs*			
Target Set 1	*Target Set 2*	*Initial overlap* *Final overlap*	*Initial overlap* *Final overlap*	*Unrelated word pairs*	
hark *rake*	schep *shovel*	haring kwark	harnas werk	vinger gladiool	viaduct riool
radijs *radish*	paprika *pepper*	raket spijs	rad anijs	beker speer	beeld weer
wortel *carrot*	knol *turnip*	wolk mortel	wonder hotel	tovenaar straat	toneel mandaat
tomaat *tomato*	pompoen *pumpkin*	tovenaar straat	toneel mandaat	schim mat	schilderij handvat
asperge *asparagus*	prei *leek*	asbak concierge	asfalt college	dokter mandarijn	doctoraal festijn
komkommer *cucumber*	aubergine *eggplant*	koffer zomer	konijn vlonder	haai kamer	hart water
venkel *fennel*	ui *onion*	vensterbank enkel	vergiet artikel	baard disco	banket credo